



## Course guides

# 32115 - OFT - Optical Fibre Telecommunications

**Last modified:** 13/05/2015

**Unit in charge:** Barcelona School of Telecommunications Engineering  
**Teaching unit:** 739 - TSC - Department of Signal Theory and Communications.

**Degree:** ERASMUS MUNDUS MASTER'S DEGREE IN RESEARCH ON INFORMATION AND COMMUNICATION TECHNOLOGIES (Syllabus 2009). (Optional subject).  
MASTER'S DEGREE IN RESEARCH ON INFORMATION AND COMMUNICATION TECHNOLOGIES (Syllabus 2009). (Optional subject).

**Academic year:** 2015    **ECTS Credits:** 6.0    **Languages:** English

### LECTURER

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**Coordinating lecturer:** GABRIEL JUNYENT GIRALT

**Others:** JOSEP SOLÉ-PARETA, JAUME COMELLAS COLOMÉ

### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

3. Ability to implement wired/wireless systems, in both fix and mobile communication environments.
4. Ability to design and dimension transport, broadcast and distribution networks for multimedia signals

**Transversal:**

1. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
2. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

### TEACHING METHODOLOGY

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Lectures  
Group work (distance)  
Individual work (distance)  
Oral presentations  
Other activities  
Extended answer test (Final Exam)

## LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject:

The aim of this course is to train students in methods of analysis, design and evaluation of technologies for Optical Fiber Telecommunications. First, we consider the main elements of optical network transmission systems, with special focus on the evolution of DWDM (fixed grid to gridless) very high bit rate networks. Then, different technologies of current as well as future IP/WDM networks and the role of optical technologies for the cloud era are reviewed

Learning results of the subject:

- Ability to analyse, specify, design networks, services, processes and applications of telecommunications in fixed, local or long distance, with different bandwidths in IP over Optical Networks.
- Ability to apply both traffic engineering tools as planning tools, dimensioning and network analysis.
- Ability to analyse, model and implement new architectures, network protocols and communication interfaces and new network services and applications.

## STUDY LOAD

Type	Hours	Percentage
Hours large group	39,0	31.20
Self study	86,0	68.80

**Total learning time:** 125 h

## CONTENTS

### 1. Introduction

**Description:**

Optical fiber communications evolution:  
 From Multi-Mode Fiber (MMF) to Single Mode Fiber (SMF)  
 From SMF to Multi-Core Fiber (MCF)  
 From SMF to Few-Mode Fiber (FMF)  
 From Intensity Modulation to Coherent Systems  
 From Single Optical Channel Transmission to Dense Wavelength Division Multiplexing (DWDM) WDM and Space Division Multiplexing (SDM)  
 From DWDM single channel ( $\lambda$ ) to Superchannel  
 From Point to Point Optical Fiber Transmissi3n to Optical Networks  
 Optical and higher layers are converging with SDN  
 Optical fibre telecommunications-networks for the cloud age

### 2. Optical Fiber Transmission Technologies

**Description:**

Optical Fiber Transmission Technologies:  
 Intensity Modulation and Direct Detection  
 Coherent Transmission with Heterodyne Detection  
 WDM  
 DWDM  
 CWDM  
 Superchannels  
 SDM  
 Metropolitan Networks  
 Core Networks

### 3. Key Devices, Components and Subsystems for optical fiber telecommunication

**Description:**

Key Devices, Components and Subsystems for optical fiber telecommunications:

Optical fibers: physical impairments and compensations

Transceivers: transmitters+receivers

Pluggable optics for transceivers

Optical filters

Optical Multiplexer and Demultiplexer

Optical amplifiers

Reconfigurable Optical Add-Drop Multiplexers (ROADM): Evolution and technologies

Multidegree ROADM

Optical Switchers

Subsystems for Optical Signal Monitoring and Digital Signal Monitoring

Digital Signal Processing by FPGAs

Photonic Integrated Circuits (PIC)

### 4. Evolution of Optical Fibre Telecommunication Technologies

**Description:**

Evolution of Optical Fibre telecommunication Technologies:

New developments in Optical Transport Networking (OTN)

Ethernet+OTU (FEC)+Tunable transponders+ROADM+Control Plane

Forward Error Technologies (FEC)

Evolution of Transport Plane: from fixed grid to elastic or gridless technologies

WDM Flexgrid

Advanced Multi-degree ROADM Architectures

Future Flexible Optical Node

Advanced Modulation Formats- Coherent Systems

Technologies for 100G and beyond

OFDM

Superchannel Technologies: toward terabit linecards

An optical transmitter for every need

Transponders: Bandwidth Variable Transponders with reconfigurable modulation format

Technologies for high capacity transmission using SDM and FMFs

### 5. Transporting IP traffic over optical networks

**Description:**

Transporting IP traffic over optical networks:

IP/GbE/WDM

Optical Networks: IP/OTN, IP/ASON, GMPLS

Optical burst and packet switching Evolution to SDN networks



## 6. Optical Technologies for Cloud Era

### Description:

Optical Technologies for Cloud era:  
Cloud Computing: Transforming Information Technology  
Software Defined Networks (SDN)  
What is OpenFlow?  
How SDN will alter optical transport  
Network Functions Virtualization  
Transformation to virtual-network infrastructures  
Optical technologies trends for clouds datacenters: transitioning from copper to fiber  
Intra and inter Data Center Interconnections  
Carrier SDN: drivers and evolution

## ACTIVITIES

### EXERCISES

#### Description:

Exercises to strengthen the theoretical knowledge.

Technical Report:

This activity will consist of preparing a Technical work, in groups of 2 or 3 students, which will have to be presented to the rest of the class at the end of the course.

#### Material:

For this course ATENEA will be the virtual teaching support tool. From there the students will be able to download all the documents (slides, related papers, etc.) of the course.

**Full-or-part-time:** 13 h

Laboratory classes: 13h

### ORAL PRESENTATION

#### Description:

Presentation of a work group.

### EXTENDED ANSWER TEST (FINAL EXAMINATION)

#### Description:

Final examination.

## GRADING SYSTEM

Final examination: 40%

Individual assessments: 10%

Group assessments: 50% (group technical work-report)

## EXAMINATION RULES.

On the final exam students will be able to bring all kinds of technical information (slides, books, related papers of the course, etc.)



## BIBLIOGRAPHY

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### Basic:

- Perros, H.G. Connection-oriented networks: SONET/SDH, ATM, MPLS, and optical networks. Hoboken: John Wiley, 2005. ISBN 0470021632.
- Kaminow, I.P.; Li, T.; Willner, A.E. Optics and photonics : optical fiber telecommunications: VI A: components and subsystems [on line]. 6th ed. St. Louis, MO: Academic Press, 2013 Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10698605>. ISBN 9780123972354 (VOL. A).
- Kaminow, I.P.; Li, T.; Willner, A.E. Optics and photonics: optical fiber telecommunications, VI B: systems and networks [on line]. 6th ed. St. Louis, MO: Academic Press, 2013 Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10713017>. ISBN 9780123972378 (VOL. B).
- Mukherjee, B. Optical WDM networks. New York: Springer, 2006. ISBN 0387290559.

### Complementary:

- Black, U.D. Optical networks : third generation transport systems. Upper Saddle River, NJ: Prentice Hall, 2002. ISBN 0130607266.
- Tomsu, P.; Schmutzer, C. Next generation optical networks: the convergence of IP intelligence and optical technology. Upper Saddle River: Prentice Hall, 2002. ISBN 013028226X.
- Ramaswami, R.; Sivarajan, K.N.; Sasaki, G.H. Optical networks: a practical perspective [on line]. 3rd ed. San Francisco: Morgan Kaufmann, 2010 [Consultation: 31/07/2013]. Available on: <http://www.sciencedirect.com/science/book/9780123740922>. ISBN 9780123740922.
- Desurvire, E. Wiley survival guide in global telecommunications: broadband access, optical components and networks, and cryptography. Hoboken, NJ: John Wiley & Sons, 2004. ISBN 0471675202.
- Keiser, G. Optical fiber communications. 4th ed. New York: McGraw-Hill, 2011. ISBN 9780073380711.
- Hui, R.; O'Sullivan, M. Fiber optic measurement techniques. Burlington, MA: Academic Press/Elsevier, 2009. ISBN 9780123738653.
- Chan, C.C.K. Optical performance monitoring: advanced techniques for next-generation photonic networks. Amsterdam ; Boston: Academic Press, 2010. ISBN 9780123749505.
- Walrand, J.; Varaiya, P.P. High-performance communication networks [on line]. 2nd ed. San Francisco, CA: Morgan Kaufmann, 2000 [Consultation: 16/02/2015]. Available on: <http://www.sciencedirect.com/science/book/9781558605749>. ISBN 1558605746.

## RESOURCES

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### Hyperlink:

- ATENEA. For this course ATENEA will be the virtual teaching support tool. From there the students will be able to download all the documents (slides, related papers, etc.) of the course.